Effect of Incomplete Acquisitions on the Image of High Resolution Preclinical Scanners

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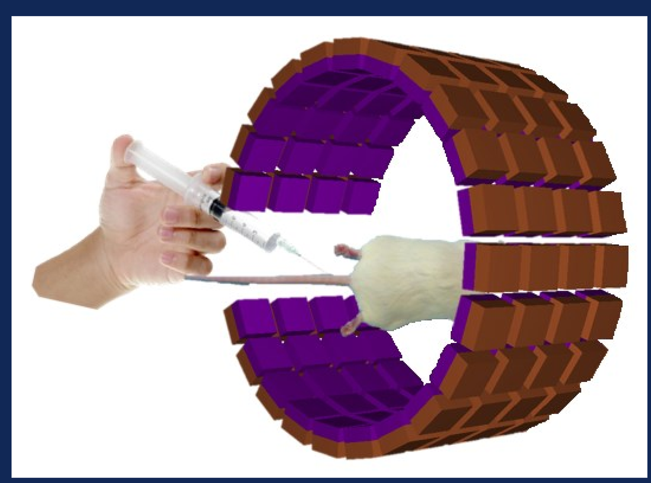
INTRODUCTION

In general, PET scanners are designed with cylindrical geometry [1-3], to homogeneously sample the object, and obtain the best image with uniform resolution and sensitivity along the full transaxial and axial field of view (FOV). However there are natural gaps between detectors and rings that reduce the sensitivity in different regions of the FOV. The reconstruction software ia prepared to face these gaps, but there are not studies considering asymmetric gaps due to the lack of some detectors. In this work, we have considered two different cases for the Super Argus PET/CT scanner (4 ring version) [1]:

1) Random detectors failure.

2) Removing a whole scanner section.



1) Random detectors failure

In this case, we have randomly selected a given number of detectors and eliminated all the coincidences with them. Standard EMML algorithm is then applied to reconstruct the image.

In fig. 1 and fig. 2, we have evaluated the Image Quality (IQ) phantom from the NEMA NU 4-2008 [6] standard.

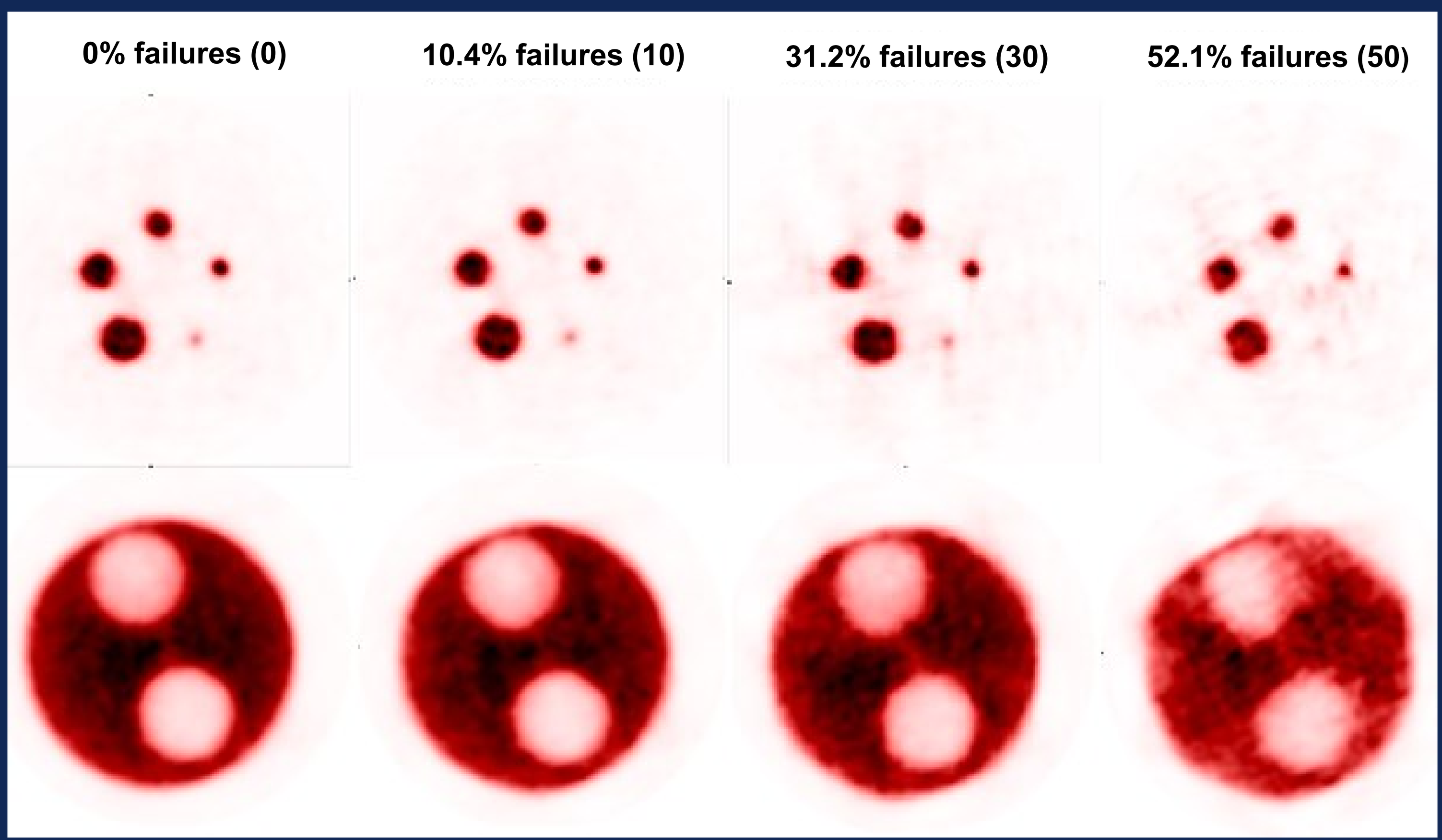


Figure 1. Examples of transversal slice of the five rods (up) and the spill over cylinders (down) reconstructed with 0, 10, 30 and 50 detector failures using 20 iterations of the EMML algorithm.

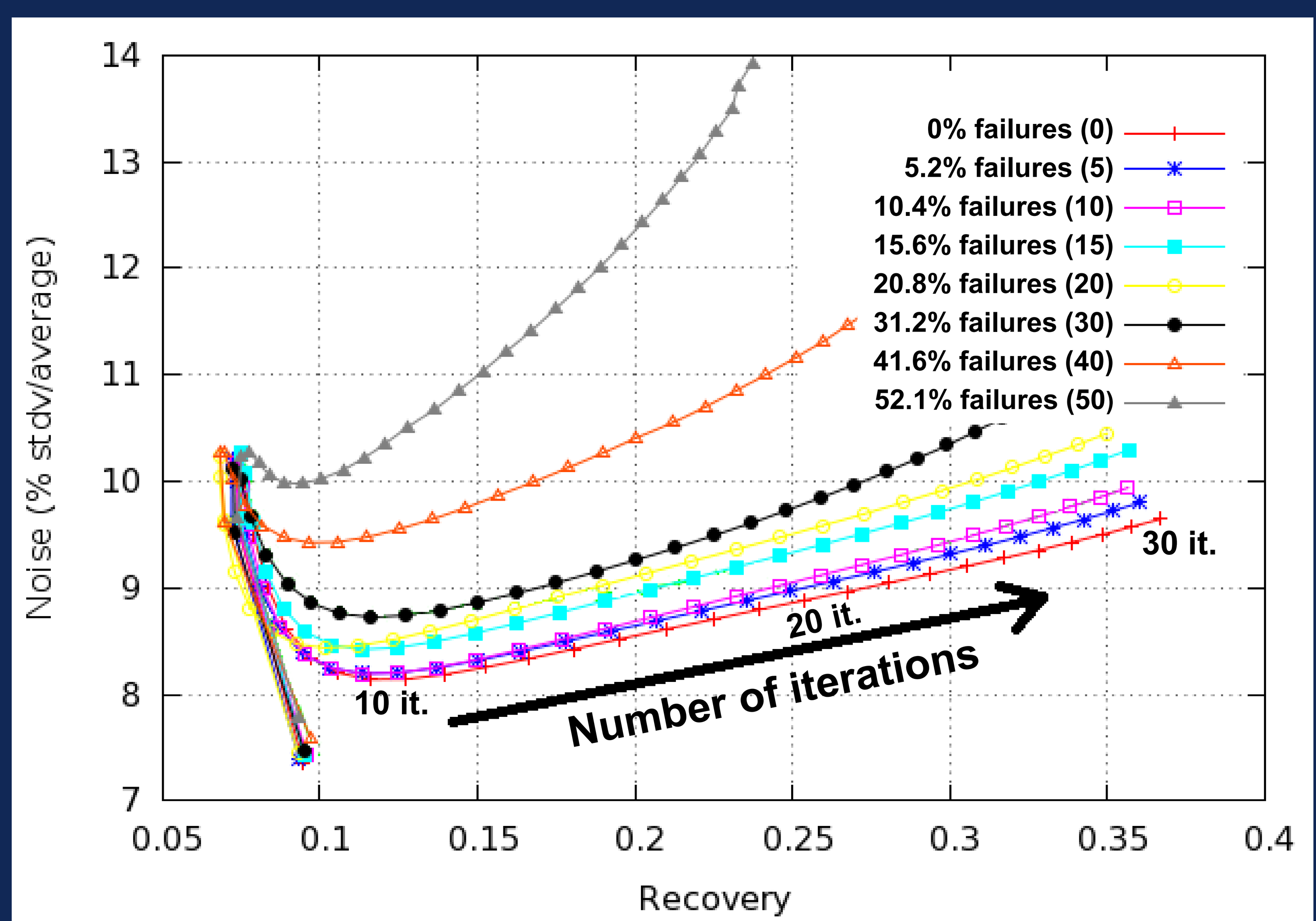


Figure 2. Recovery coefficient – noise evolution for the 1mm diameter rod measured on the IQ phantom. Each dot corresponds to one iteration (up to 30) of the EMML reconstruction. No detector removal case is shown in red, the section removal case is represented in green, and the rest of the curves correspond to a given number of random failures. The number of iterations evolves from left to right, raising both noise and RC after a certain number of iterations as indicated by the black arrow.

2) Removing a whole scanner section

After removing a whole scanner section, will find a lack of information for a large region of the sinogram, causing visible artifacts, besides affecting the image quality parameters. This scanner design will be useful for dynamical researches in which we are interested in interacting with the patient (inject additional radiotracer, guide a catheter, etc.) or for real-time imaging PET applications [4, 5].

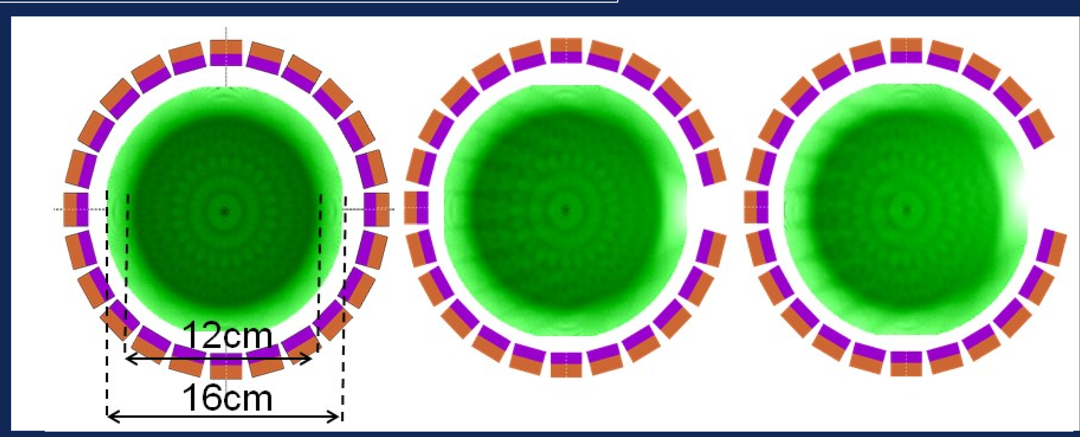


Figure 3. Map of sensitivity in the central slice of the scanner (left), and after removing 1 (central) and 2 sections (right).

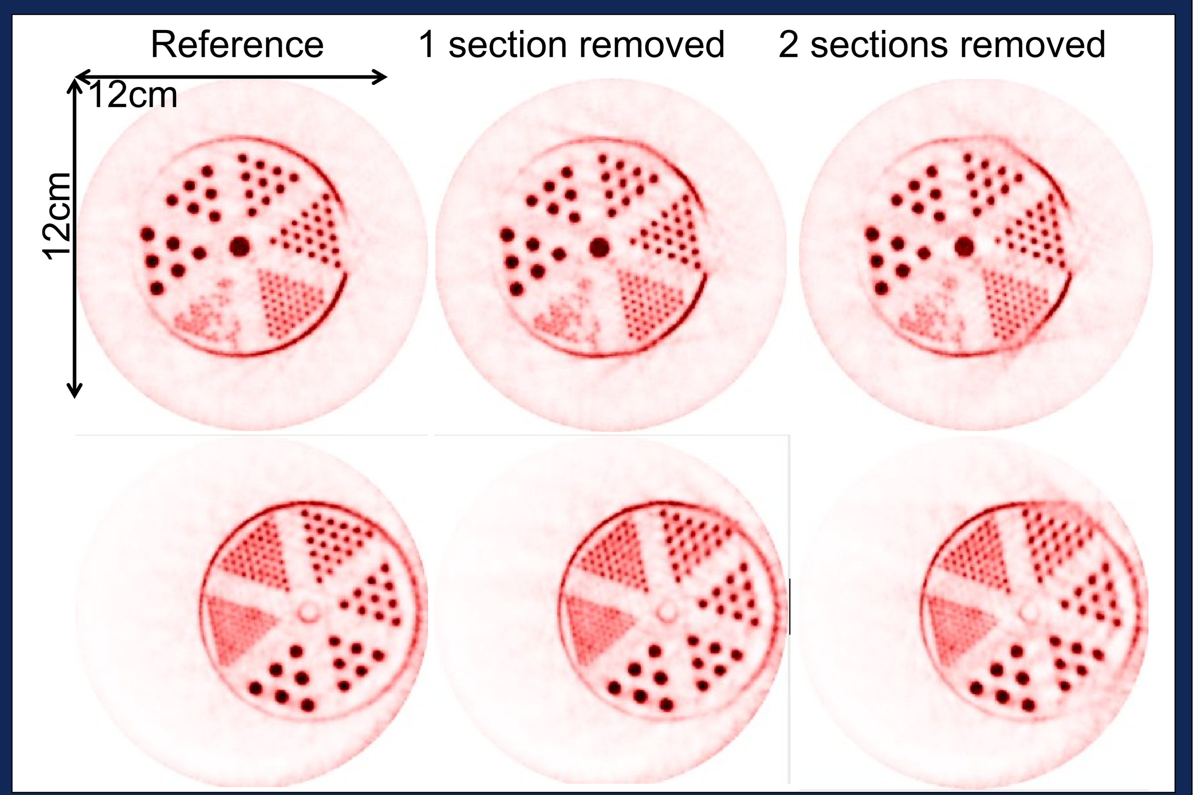


Figure 4. Reconstructed Derenzo in the center of the scanner (up) and displaced toward the missing sections (down). For the centered phantom, we observe some artifacts in the border of the phantom, but no effect over the rods. However, when we displace the phantom, we can also see some stretching of the rods.

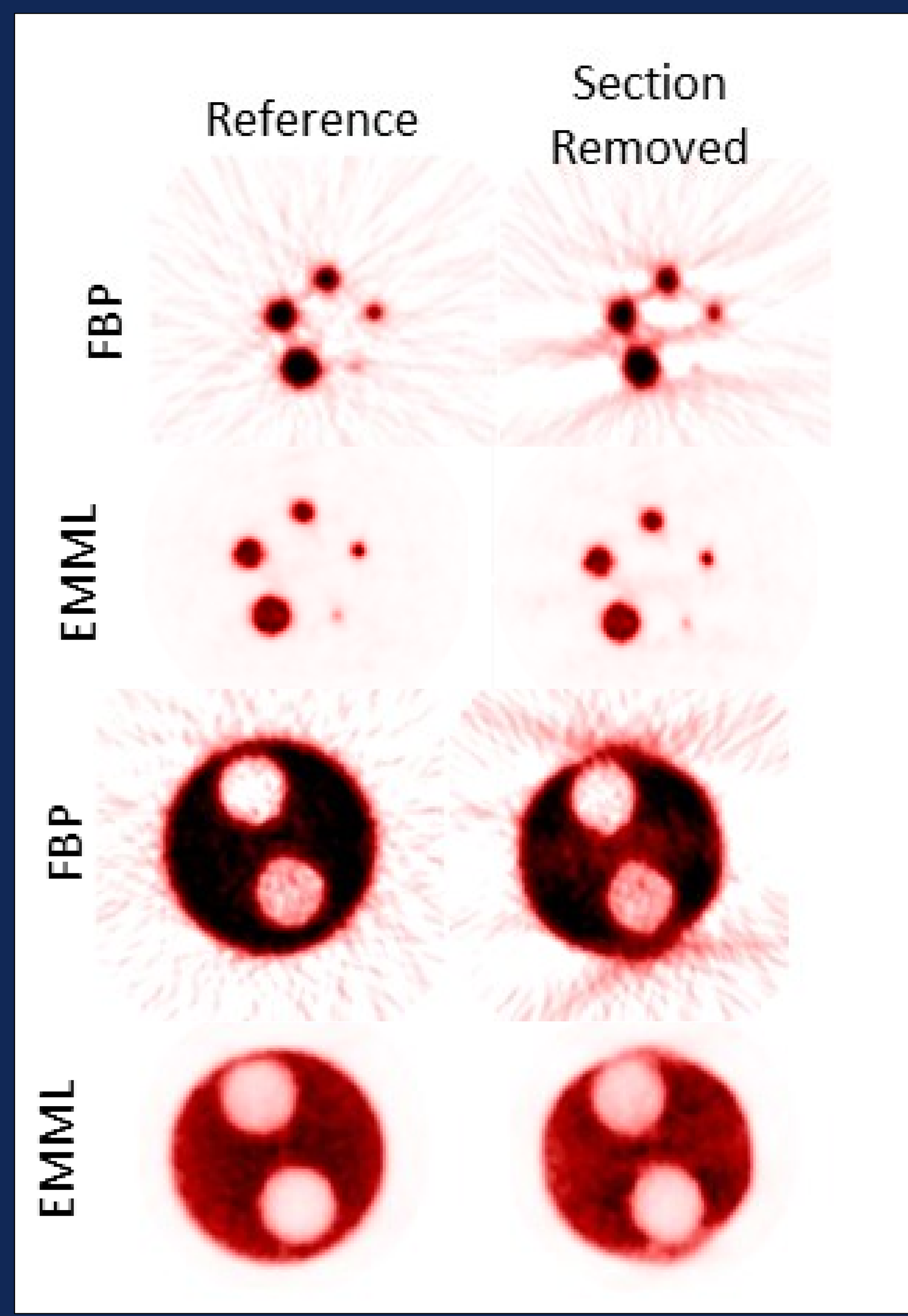


Figure 5. Examples of transversal slice of the five rods (up) and the spill over cylinders (down) reconstructed with the full scanner (reference) and after removing a scanner section, using FBP and EMML (20 iterations).

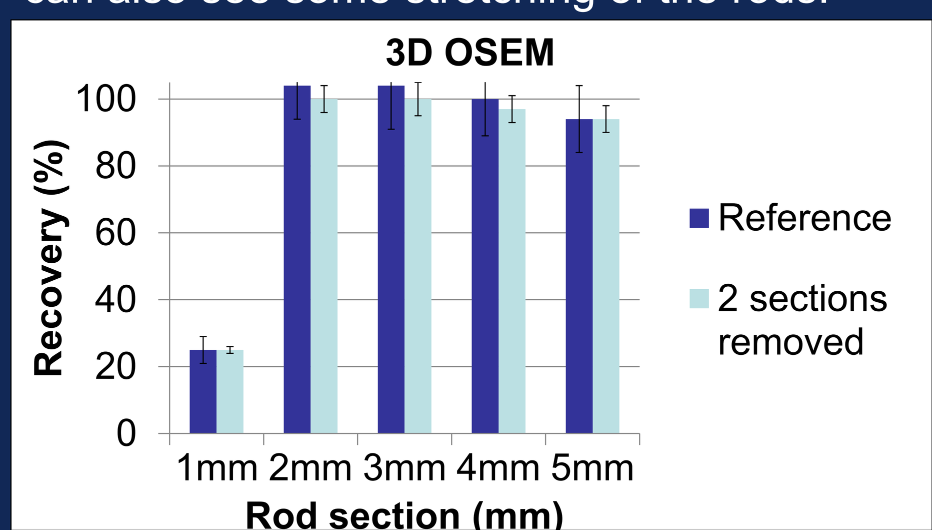


Figure 6. Measured RC and noise according to the NEMA NU 4–2018 of the images in fig. 5. EMML values with a removed section (R. S.) were averaged over the removal of eight equally spaced sections (that is why it has lower errors). Lower RC values are measured after removing the sections, although the results are still competitive. The noise for the reference image raised from 8.8% to 9.3% after removing the sections.

Conclusions

- Effects of incomplete acquisitions have been quantitatively measured against the number of eliminated detectors for Super Argus 4R preclinical scanner.
- No remarkable image quality detriment has been observed up to 5 randomly selected missing detectors, or 5% of the total.
- Resolution loss and artifact formation has been observed when a full axial section of detectors is removed.
- Image quality has not been affected in the center of the scanner by the removal of an axial scanner section for the OSEM 3D reconstruction.
- Further studies are ongoing to quantitatively measure the resolution impact on the image in the different regions of the FOV.
- Regularization methods and other corrections will be considered to prevent artifacts.

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This work was supported by Comunidad de Madrid (S2013/MIT-3024 TOPUS-CM), Spanish Ministry of Science and Innovation, Spanish Govenrment (FPA2015-65035-P, RTC-2015-3772-1). J. L. Herraiz is also funded by the EU Cofund Fellowship Marie Curie Actions, 7th Frame Program, P. Galve is supported by a Universidad Complutense de Madrid, Moncloa Campus of International Excellence and Banco Santander predoctoral grant, CT27/16-CT28/16. This is a contribution for the Moncloa Campus of International Excellence. Grupo de Física Nuclear-UCM,Ref.: 910059. This work acknowledges support by EU's H2020 under MediNet a Networking Activity of ENSAR-2 (grant agreement 654002). Thank to SEDECAL for providing the data analyzed in this work and to the Laboratory of Medical Imaging – Hospital General Gregorio Marañón (LIM-HGGM).